construction
engineering
research
laboratory

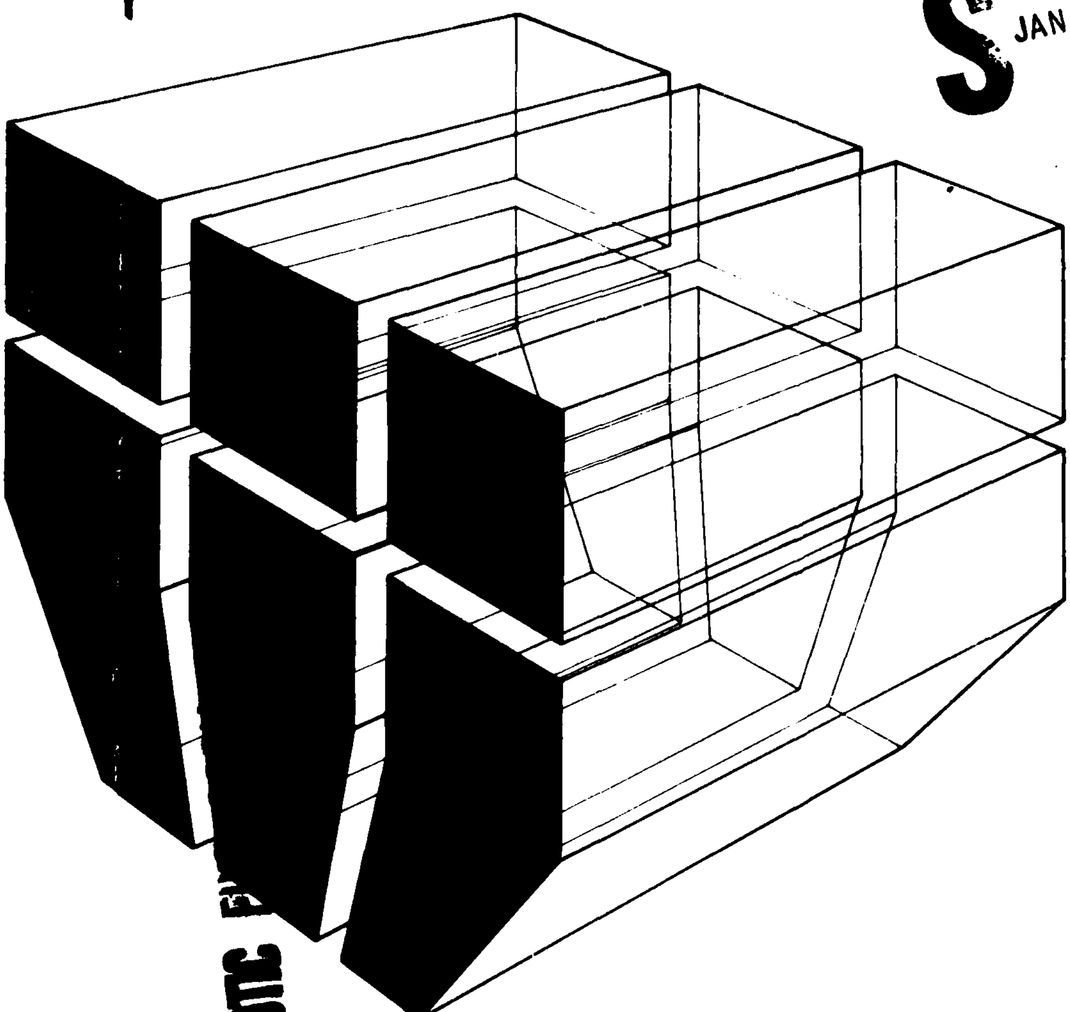
United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

TECHNICAL REPORT N-113
September 1981
Interdependency of Elements in Ecological Systems

12

LEVEL II

EFFECTS OF TACTICAL VEHICLE ACTIVITY ON THE MAMMALS, BIRDS, AND VEGETATION AT FORT HOOD, TEXAS



by
W. D. Severinghaus
W. D. Goran
G. D. Schnell
F. L. Johnson

Approved for public release; distribution unlimited.

USER EVALUATION OF REPORT

REFERENCE: Technical Report N-113, *"Effects of Tactical Vehicle Activity on the Mammals, Birds, and Vegetation at Fort Hood, Texas"*

Please take a few minutes to answer the questions below, tear out this sheet, and return it to CERL. As a user of this report, your customer comments will provide CERL with information essential for improving future reports.

1. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

____

____

____

2. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.) ______________________________

____

____

3. Has the information in this report led to any quantitative savings as far as man-hours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate. ______________________________

____

____

4. What is your evaluation of this report in the following areas?

   a. Presentation: ______________________________

   b. Completeness: ______________________________

   c. Easy to Understand: __________________________

   d. Easy to Implement: ___________________________

e. Adequate Reference Material: ______________________

f. Relates to Area of Interest: ______________________

g. Did the report meet your expectations? ______________________

h. Does the report raise unanswered questions? ______________________

i. General Comments (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.) ______________________

____

____

____

____

5. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name: ______________________

Telephone Number: ______________________

Organization Address: ______________________

____

____

6. Please mail the completed form to:

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
ATTN: CERL-SOI
P.O. Box 4005
Champaign, IL 61820

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER CERL-TR-N-113	2. GOVT ACCESSION NO. AD A109 646	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EFFECTS OF TACTICAL VEHICLE ACTIVITY ON THE MAMMALS, BIRDS, AND VEGETATION AT FORT HOOD, TEXAS		5. TYPE OF REPORT & PERIOD COVERED FINAL 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) W. D. Severinghaus W.D. Goran G. D. Schnell F. L. Johnson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005, Champaign, IL 61820		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AT23-C-001
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE September 1981 13. NUMBER OF PAGES 22
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from the National Technical Information Service
Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

mammals
birds
vegetation
natural history
Ft Hood, TX
tracked vehicles

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A field study was conducted at Fort Hood, TX, to investigate the effects of Army tracked vehicle training on the resident mammal, bird, and plant populations. This report: (1) describes preliminary indications of ecological differences between selected areas used for vehicle training and areas undisturbed by training, (2) documents the procedures used to obtain this information, and (3) analyzes Fort Hood's ecosystem to verify the effects of training activities on ecosystems examined in previous research.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

FOREWORD

This investigation was performed by the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory (CERL) under Work Unit AT23-C-001, "Interdependency of Elements in Ecological Systems." The authors would like to acknowledge field assistants Robert E. Riggins, Mary C. Severinghaus, and Dan Roldan. Others involved in the study were Dave Palmer, Doug Turney, Norman Dunbar, and Fred Bruier.

Dr. R. K. Jain is Chief of EN. COL L. J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

TABLES

FIGURES

EFFECTS OF TACTICAL VEHICLE ACTIVITY ON THE MAMMALS, BIRDS, AND VEGETATION AT FORT HOOD, TEXAS

1 INTRODUCTION

Background

Recent trends in environmental impact analysis require that impact estimates be quantified; using analytical models is one effective way of doing this. But because appropriate cause and effect relationships between Army activities and their impacts on ecosystems have not been established, ecological modeling is not now feasible.

This report is the second of a series documenting basic ecological research conducted to establish these cause-effect relationships. The first report described the effects of tracked vehicle activity on the ecosystem of Fort Knox, KY.[1] Further significant findings will be documented as they occur during later research, which will study the quantification of impacts on soil, water, and other parts of the ecosystem.

Objective

The overall objective of this study is to determine Army activities' effects on ecosystems. The objectives of the phase of the study detailed in this report are: (1) to describe preliminary indications of ecological differences between selected areas used for Army tracked vehicle training and areas undisturbed by training, (2) to document the procedures used to obtain this information, and (3) to analyze Fort Hood's ecosystem to verify tactical vehicle cause-effect relationships established in previous research.

Approach

Extensive field surveys were conducted at selected sites at Fort Hood, TX, to establish the effects of tracked vehicle training on birds, small mammals, and vegetation.

2 GENERAL SITE DESCRIPTION

Two sites were chosen for quantitative sampling, based on the following criteria: the areas were to be similar in soils, topography, and plant species composition; one of the sites was to be heavily used for tracked vehicle training; and the other was to be relatively undisturbed.

The two study areas are on Fort Hood Military Reservation west of Temple in central Texas (31°05'N, 97°45'W). Fort Hood is in the southern portion of the Cross Timbers and Prairie Vegetational Area.[2] The flora of Fort Hood is influenced by the Edwards Plateau Vegetational Area about 80 km to the southwest, and the Blackland Prairie, which is immediately to the east.

The relatively undisturbed site (point C, Figure 1), which will be called the "control area," is at 258468 on the Defense Mapping Agency 1:50,000, 1977 Fort Hood Map. The site is about 0.5 km north of North Nolan Road and about 2 km east of East Range Road. The vegetation is typical upland woodland dominated by rock cedar *(Juniperus ashei)* and live oak *(Quercus fusiformis)*. Topography is rolling, with a combination of level ridge tops and both east- and west-facing slopes. The soil is light-colored gravelly clay. A few cedars have been cut for posts and a few old vehicle trails pass through the area, but this is true of all the upland forest observed at Fort Hood.

The tracked vehicle site, which will be called the "test area" (point T, Figure 1), is at 075560 on the 1977 Fort Hood map. The site is adjacent to the east side of Antelope Road, about 1 km south of Table Rock Creek. The vegetation consists of "islands" of trees in a network of heavily used tracked vehicle trails. Plant species composition, at least for the woody plants, conforms to typical rock cedar-live oak. Topography and soils are very similar to the control area, except that much of the topsoil along the vehicle trails has eroded, leaving the very light-colored gravelly clay subsoil exposed. The area is highly disturbed—63 percent of a set of 60 randomly placed points fell in recently traveled vehicle trails.

3 METHODS

The mammal and bird surveys were conducted between 14 April and 3 May 1979. The vegetation studies were done between 22 and 27 May 1979.

Vegetation

Vascular plants were divided into three categories for phytosociological sampling: (1) trees—plants woody stems greater than or equal to 50 mm in diameter at a height of 1.5 m; (2) small woody vegetation—plants with woody stems less than 50 mm in diameter at a height of 1.5 m (this category includes saplings, tree seedlings, shrubs, woody vines, and

[1] W. D. Severinghaus, R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds, and Vegetation at F Knox, KY*, Special Report N-77/ADA073782 U.S. Army Construction Engineering Research Laboratory [CERL], July 1979).

[2] F. W. Gould, *Texas Plants—A Checklist and Ecological Summary* (Texas A&M University, Texas Agricultural Experiment Station, MP-585/REV., 1975).

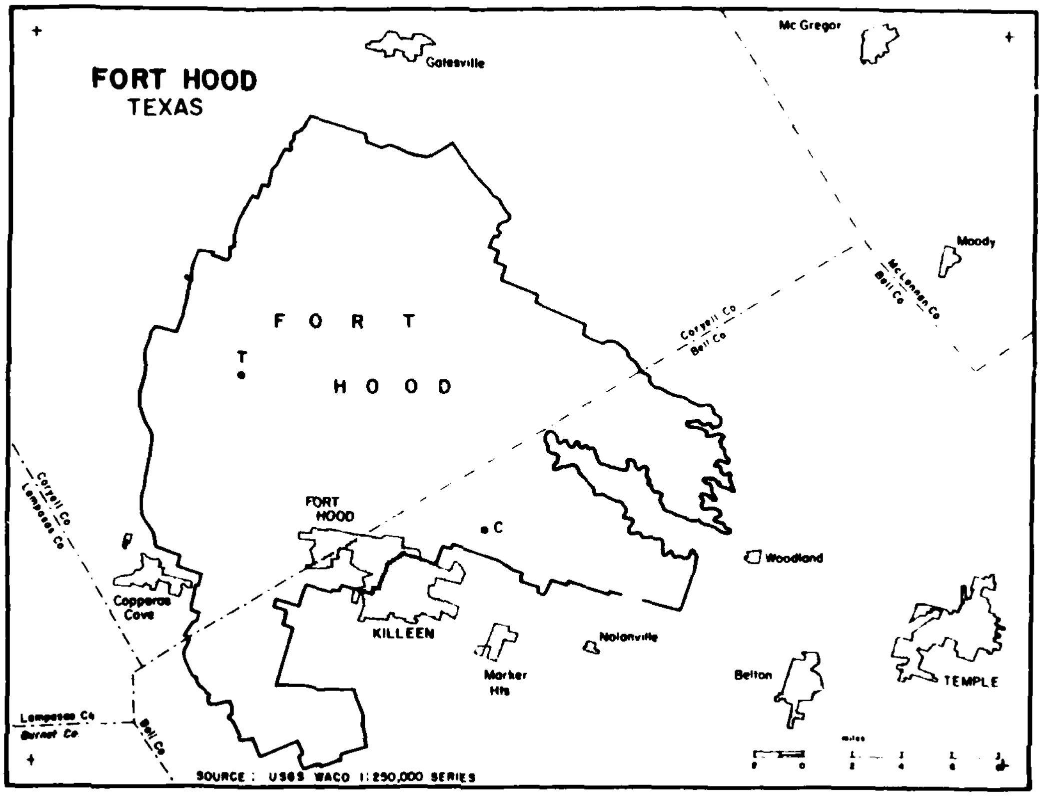


Figure 1. Fort Hood, TX (T = test area, C = control area).

cacti); and (3) herbaceous plants—vascular plants without perennial above-ground parts.

Trees were sampled for density, frequency, and basal area with an augmented variable-radius method.[3] At 30 stratified, random points in each stand, basal area was estimated for each tree species with a 10-BAF prism.[4] For density and frequency estimates, all trees were counted by species in an 18.3-m diameter circular quadrat. At an additional eight randomly selected points in each stand, diameters were measured on all trees within an 18.3-m diameter circle for size-class distribution data. Total area sampled for trees was 1 ha in each stand. Increment cores were taken from several trees of the two dominant species for correlation of age with diameter.[5] Total tree canopy cover was estimated in each of the circular quadrats.

Small woody vegetation was sampled in circular quadrats, 6.1 m in diameter, at the centers of 30-tree quadrats in each stand. Plants were counted by species for density and frequency calculations, and percent cover was estimated for each species.

Herbaceous plants were sampled in 0.5-m^2 quadrats at the centers of 30-tree quadrats in each stand. Plants were counted by species for density and frequency calculations, and percent cover was estimated for each species.

Absolute and relative values for frequency, density, and dominance were calculated for each species in the three categories of vegetation.[6] Importance percent-

---

[3]E. L. Rice and W. T. Penfound, "An Evaluation of the Variable-Radius and Paired-Tree Methods in the Blackjack-Post Oak Forest," *Ecology*, Vol. 36 (1955), pp 315-320.

[4]D. Bruce, "A New Way to Look at Trees," *Journal of Forestry*, Vol. 53 (1955), pp 163-167.

[5]M. A. Stokes and T. L. Smiley, *An Introduction to Tree-Ring Dating* (University of Chicago Press, 1968).

[6]Bruce, pp 163-167; G. W. Cox, *Laboratory Manual of General Ecology* (W. C. Brown Co., 1967).

ages were calculated for each species by taking the mean of relative frequency, relative density, and relative dominance for that species. A t-test was used for evaluating differences.[7] Shannon-Wiener diversity was calculated for each vegetation category in each stand.[8]

Linear regression equations were derived from tree-ring data and used to convert the measured diameters to age classes. The resulting age-class distributions were tested to determine which distribution model best described the two woodlands.[9]

Soil

Soil compaction was measured at 60 points in each stand (i.e., two points 0.5 m from each of 30-tree quadrat centers). The instrument used was a Soil-test model CL-700 penetrometer. To measure soil surface disturbance, transects were walked through the study sites, and the number of steps for which there was any sign of man-made disturbance was divided by the total number of steps to obtain a soil surface disturbance index (SSDI).

Birds

The survey methods used in this study combined the procedures of Emlen, Severinghaus, and Balph, Stoddart, and Balph.[10] Biomass information (the number or weight of all organisms of a given designation in a specified habitat or region) was obtained by combining the information presented in Norris and Johnson, Behle, Graber and Graber, Esten, Baldwin and Kendeigh, Poole, Amadon, and Oberholser.[11]

Mammals

Small mammal trapping was conducted at Fort Hood during the spring of 1979 on both the control and test sites. At the control site, trap lines were run from 22 April through 1 May, with a total of 1864 trap nights. The test site was trapped from 23 April through 1 May, with a total of 2038 trap nights.

Traps were set out across the control and test areas along line transects, with individual traps generally set at about a 10-pace (8- to 9-m) interval. Each trap line was baited for two consecutive nights; then the traps were removed and a new line was set out at another location within the control or test area. Specimens captured were examined and measured for species identification, and skins and skulls were prepared for museum use. These specimens are housed at the U.S. Army Construction Engineering Research Laboratory (CERL).

The results at the two sites were compared using a capture index, which is the number of individuals of each species captured divided by the number of trap nights multiplied by 1000. Also, a chi-square test was used to compare the populations of the three major species captured at the control and test sites. Comparisons were made of the biomass of each of these species, and of the species by guild type.

4 RESULTS

Vegetation

Tree species composition (Table 1) is reasonably similar in the two areas selected for detailed study. The coefficient of community[12] of the tree stratum in the two areas is 0.73 on a scale of 0 (least similar) to 1.0 (identical). Both stands are dominated by rock cedar and live oak. Post oak *(Quercus stellata)*, Texas oak *(Q. texana)*, and Cedar elm *(Ulmus crassifolia)* are common upland trees in central Texas and are found in both study areas.

The only significant difference between the tree vegetation of the study areas is in density and percent cover (Table 2). The control area has 1.7 times as many trees as the test area. The control area has 2.6 times the aerial cover and 2.5 times the basal cover of the test area. Tree species diversity is about the same in both, with 1.39 in the control and 1.48 in the test area.

Species composition of the small woody vegetation in the two study areas is similar (Table 3). However,

[7] Cox, p 165.

[8] Cox, p 165.

[9] F. L. Johnson and D. T. Bell, "Size-Class Structure of Three Streamside Forests," *American Journal of Botany*, Vol. 62 (1975), pp 81-83.

[10] J. T. Emlen, "Population Densities of Birds Derived from Transect Counts," *Auk*, Vol. 88 (1971), pp 323-342; J. T. Emlen, "Estimating Breeding Bird Densities from Transect Counts," *Auk*, Vol. 94 (1977) pp 455-468; W. D. Severinghaus, *Guidelines for Terrestrial Ecosystem Survey*, Technical Report N-89 ADA086526 (CERL, May 1980); M. H. Balph, L. C. Stoddart, and D. F. Balph, "A Simple Technique for Analyzing Bird Transect Counts," *Auk*, Vol. 94 (1977), pp 606-607.

[11] R. A. Norris and D. W. Johnson, "Weights and Weight Variations in Summer Birds from Georgia and South Carolina," *Wilson Bulletin*, Vol. 70, No. 2 (1958), pp 114-129; W. N. Behle, "Weights of Some Western Species of Horned Larks," *Auk*, Vol. 60 (1943), pp 216-221; R. R. Graber and J. W. Graber, "Weight Characteristics of Birds Killed in Nocturnal Migration," *Wilson Bulletin*, Vol. 74, No. 1 (1962), pp 74-88; S. R. Esten, "Bird Weights of 52 Species of Birds (Taken from Notes of William Van Goider)," *Auk*, Vol. 48 (1931), pp 572-574; S. R. Baldwin and S. C. Kendeigh, "Variation in the Weight of Birds," *Auk*, Vol. 55 (1938), pp 416-467; E. L. Poole, "Weights and Wing Areas in North American Birds," *Auk*, Vol. 55 (1938), pp 513-518; D. Amadon, "Bird Weights and Egg Weights," *Auk*, Vol. 60 (1943), pp 221-234; H. C. Oberholser, *The Bird Life of Texas*, 2 Vols. (University of Texas Press, 1974).

[12] G. W. Cox, *Laboratory Manual of General Ecology* (W. C. Brown Co., 1967).

Table 1

Tree Data Summary

Species (Scientific Names)	Control Area RF*	RD	RBA	IP	Tank Training Area RF	RD	RBA	IP
Bumelia lanuginosa	--	--	--	--	2.8	1.2	0.5	1.5
Celtis reticulata	--	--	--	--	5.5	1.6	0.0	2.4
Cercis canadensis	1.0	0.2	0.0	0.4	1.4	0.4	0.0	0.6
Juniperus ashei	34.0	43.9	47.0	41.6	31.9	28.7	26.3	29.0
Prunus mexicana	2.0	0.9	0.6	1.2	--	--	--	--
Quercus fusiformis	30.0	34.0	36.8	33.6	37.5	35.6	38.5	37.2
Q. marilandica	4.0	0.9	1.7	2.2	--	--	--	--
Q. sinuata	10.0	11.3	6.8	9.4	--	--	--	--
Q. stellata	4.0	1.9	3.3	3.1	1.4	4.9	10.9	5.7
Q. texana	5.0	4.2	1.4	3.5	13.9	23.5	20.6	19.3
Rhus lanceolata	1.0	0.2	0.1	0.4	--	--	--	--
Ulmus crassifolia	7.0	1.9	2.4	3.8	5.5	4.0	3.2	4.2
Viburnum rufidulum	2.0	0.5	0.0	0.8	--	--	--	--

*RF = relative frequency
RD = relative density
RBA = relative basal area (= relative dominance)
IP = importance percentage

Table 2

Comparison of Cover and Density Data Between the Control Area and the Tank Training Area

	Control	Tank Training Area
Basal area of trees (m^2/ha)	10.4	4.4
Aerial cover of trees (%)	53.3	20.5
Number of trees/per hectare	426	247
Aerial cover of woody understory (%)	44.8	14.1
Number of woody understory plants per hectare	12,980	4,320
Aerial cover of herbaceous plants (%)	19.9	13.8
Number of herbaceous plants per hectare	195,900	606,800
Total cover (%)	118.0	48.4

Table 3

Summary of Small Woody Vegetation (Includes Saplings, Tree Seedlings, Shrubs, Woody Vines, and Cacti)

Species (Scientific Names)	Control Area*				Tank Training Area			
	RF	RD	RC	IP	RF	RD	RC	IP
Bumelia lanuginosa	0.5	0.1	0.2	0.3	1.7	0.3	0.7	0.9
Celtis reticulata	3.9	1.0	1.8	2.2	6.9	1.3	2.1	3.4
Cercis canadensis	3.9	3.1	1.6	2.9	--	--	--	--
Diospyros texana	11.6	11.4	21.4	14.8	5.2	2.9	12.8	7.0
Ilex decidua	1.1	0.5	1.1	0.9	--	--	--	--
Juniperus ashei	12.2	7.7	19.9	13.3	15.5	6.9	14.9	12.4
Lonicera japonica	0.5	0.2	0.2	0.3	--	--	--	--
Mimosa borealis	--	--	--	--	1.7	0.5	1.4	1.2
Opuntia phaeacantha	3.9	0.9	0.4	1.7	1.7	0.3	0.7	0.9
Prunus mexicana	0.5	2.2	0.7	1.1	--	--	--	--
Parthenocissus quinquefolia	2.8	5.5	1.6	3.3	--	--	--	--
Quercus fusiformis	9.9	9.8	8.3	9.3	3.5	3.4	0.7	2.5
Q. marilandica	0.5	0.1	1.1	0.6	--	--	--	--
Q. sinuata	5.5	8.4	19.2	11.0	--	--	--	--
Q. stellata	1.1	0.3	0.2	0.5	--	--	--	--
Q. texana	4.4	0.9	1.1	2.1	3.5	0.5	0.7	1.6
Rhus aromatica	3.9	8.2	4.0	5.4	19.0	47.1	34.8	33.6
R. lanceolata	0.5	0.3	0.4	0.4	6.9	2.1	2.8	3.9
R. toxicodendron	12.2	27.5	9.4	16.4	10.3	19.9	5.7	12.0
Rubus trivialis	0.5	0.1	0.2	0.3	--	--	--	--
Smilax bona-nox	10.5	8.7	3.6	7.6	8.6	8.2	2.8	6.5
Ulmus crassifolia	1.1	0.2	0.4	0.6	5.2	1.3	2.8	3.1
Viburnum rufidulum	2.8	1.0	1.3	1.7	5.2	4.0	13.5	7.6
Vitis berlandieri	6.1	2.3	1.8	3.4	3.5	1.1	2.8	2.5
Zanthoxylum hirsutum	--	--	--	--	1.7	0.3	0.7	0.9

*RF = relative frequency
RD = relative density
IP = importance percentage
RC = relative cover

the coefficient of community is only 0.56. The woody understory is dominated by fragrant sumac *(Rhus aromatica)* in the tank training area, but not in the control area. Dominance of fragrant sumac in the woody understory in the test area is probably a result of the more open tree canopy. Fragrant sumac does not seem to tolerate shade well, and usually grows only where it receives direct sunlight for at least part of the day.

The actual presence or absence of a woody species in either stand cannot be attributed to disturbance or lack of disturbance. Woody understory species diversity is 2.38 in the control area and 1.76 in the test area. This difference is caused by the large number of species in the control area and the heavy dominance by one species in the test area.

The density and cover of woody understory plants (Table 2) is significantly different in the two areas. The control plot has three times as many small woody plants per hectare, and they cover 3.2 times as much area.

Herbaceous vegetation shows the greatest difference between the two plots (Table 4). The herbaceous stratum in the control area is dominated by cedar sedge *(Carex planostachys)*—which was not found in the test area—and by Texas grama grass *(Bouteloua rigidiseta)*, which is an insignificant component in the test area. The most important herb in the test area, wooly plantain *(Plantago patagonica)*, is not found in the control area. The coefficient of community is only 0.28.

The control area has slightly more herbaceous cover but many fewer individual plants than the test area (Table 2). This is because of the different nature of the herbaceous plants in the two areas. The two dominant herbs in the control area, Texas grama and cedar sedge, are perennial plants which form rather large, many-stemmed clumps. Most of the herbaceous plants found in the test area are small weedy annuals which usually have single stems. The most important herb in the test area, wooly plantain (as well as many other species of *Plantago)*, is a good indicator of disturbance, since it is seldom found anywhere but recently disturbed soil.

Table 4

Herbaceous Vegetation Summary

Species (Scientific Names)	Control Area				Tank Training Area			
	RF	RD	RC	IP	RF	RD	RC	IP
Allium canadense	--	--	--	--	7.1	3.2	1.4	3.9
Ambrosia artemisiifolia	--	--	--	--	3.0	1.0	2.9	2.3
Aristida purpurea	--	--	--	--	6.1	7.5	9.4	7.7
Bouteloua rigidiseta	18.5	16.0	50.3	28.3	1.0	0.2	0.7	0.6
Buchloe dactyloides	1.,5	1.0	0.5	1.0	--	--	--	--
Carex planostachys	29.2	52.4	31.2	37.6	--	--	--	--
Erodium texanum	--	--	--	--	5.1	0.7	2.2	2.7
Euphorbia spathulata	--	--	--	--	1.0	0.1	0.7	0.6
Evax verna	--	--	--	--	12.1	12.3	6.5	10.3
Liatris mucronata	--	--	--	--	1.0	0.1	0.7	0.6
Oxalis dillenii	--	--	--	--	1.0	0.8	0.7	0.8
Panicum hallii	3.1	1.7	0.5	1.8	1.0	0.1	0.7	0.6
Plantago patagonica	--	--	--	--	12.1	26.5	22.5	20.4
Plantago virginica	--	--	--	--	1.0	0.3	0.7	0.7
Poa arachnifera	1.5	0.4	1.5	1.1	--	--	--	--
Schrankia roemeriana	--	--	--	--	1.0	0.2	0.7	0.6
Sisyrinchium ensigerum	--	--	--	--	1.0	0.2	0.7	0.6
Stillingia texana	--	--	--	--	1.0	0.4	0.7	0.7
Stipa leucotricha	1.5	2.0	6.5	3.3	--	--	--	--
Tragia betonicifolia	6.1	2.0	0.5	2.9	5.1	2.6	3.6	3.8
Unidentified forbs	26.2	15.0	5.0	15.4	18.2	24.8	25.4	22.8
Unidentified grasses	10.8	9.2	3.5	7.8	19.2	17.3	17.4	18.0
Valerianella amarella	1.5	0.4	0.5	0.8	1.0	1.3	0.7	1.0
Verbena pumila	--	--	--	--	1.0	0.1	0.7	0.6
Vulpia octoflora	--	--	--	--	1.0	0.2	0.7	0.6

*RF = relative frequency
RD = relative density
IP = importance percentage
RC = relative cover

Age was found to have a high correlation with tree diameter in both rock cedar and live oak. Rock cedar has a diameter growth rate of 2.5 mm/yr, with an age-diameter correlation of 0.945 ($p < 0.01$). Live oak in the two stands grows at a rate of 3.66 mm/yr, with an age-diameter correlation of 0.971 ($p < 0.01$). These growth rates were used to calculate tree ages from diameter measurements. The average value of 3.08 mm/yr was used for the few trees that were not live oak or rock cedar. The age-class distributions of trees in both areas (Figure 2) fit the negative logarithmic model, which is typical of most undisturbed natural forests. Because of the type of disturbance, even the heavily damaged test area fits the "natural" model. In the test area, vegetation is completely destroyed where vehicles travel, but is relatively undisturbed in the "islands" of trees between trails. This type of disturbance reduces the biomass, cover, and number of plants without upsetting the normal size-class distribution.

The test area has no trees older than about 110 years, while the control area has trees up to 150 years old. This is probably not a result of training activities. Woody vegetation has increased along the prairie-forest border since the area was opened for settlement.[13] The forest on the test area probably became established later than that on the control area.

A reduction in plant cover is the most noticeable effect of tracked vehicle training activities on the vegetation of upland woodland at Fort Hood. The sum of tree, woody understory, and herb cover is 118 percent in the control area, and only 48 percent in the test area. Effects on species composition may be related to the size and lifespan of the plants affected. Species composition of the tree stratum is as similar

[13] F. L. Johnson and P. G. Risser, "A Quantitative Comparison Between an Oak Forest and an Oak Savannah in Central Oklahoma," *Southwest Naturalist*, Vol. 20 (1975), pp 75-84.

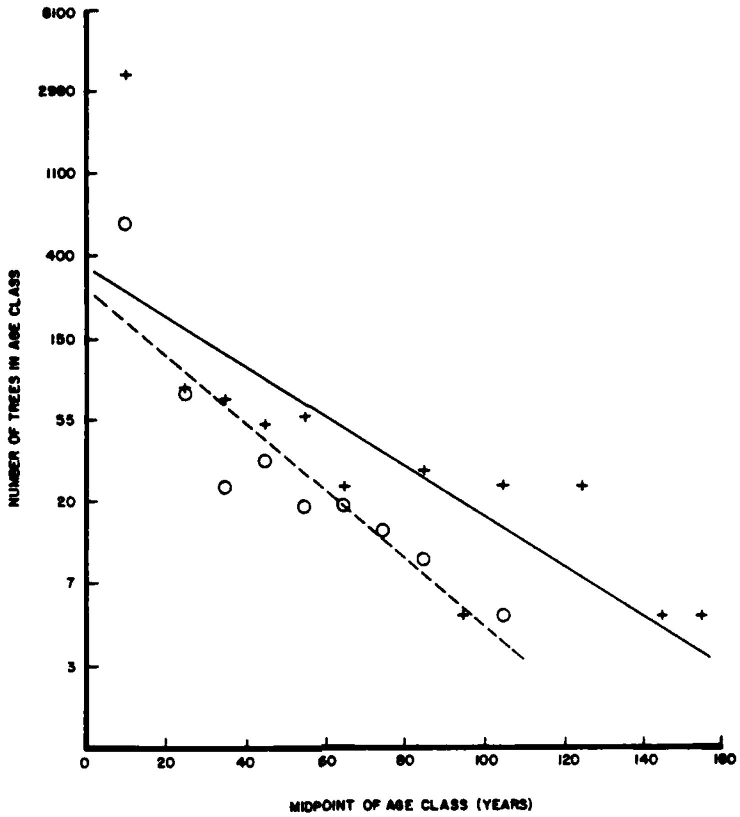


Figure 2. Comparison of age distribution of trees between control and tank training areas. (Symbols: + and solid line = control; o and dashed line = tank training area. The lines are least-squares regression lines. Note logarithmic scale on vertical axis.)

in the two stands as could be expected of two undisturbed stands in the same vegetation type. The woody understory has essentially the same species in the two areas, but the similarity (coefficient of community) is not high because the test area is dominated by species that do not tolerate shade.

The herbaceous plants show the greatest contrast in species composition. The control area is primarily composed of rather large, perennial plants, which would be expected in an undisturbed habitat. The dominant herbs in the test area are small weedy annual plants characteristic of habitats where the soil surface is frequently disturbed.

Soil

Penetrometer readings showed high variance in both areas, with a range in both stands of 0.25 to 4.5 kg/cm^2. However, the means were different enough to be statistically significant ($p<0.005$). The mean of all penetrometer readings in the control area was 1.19 kg/cm^2, while the mean for the test area was 2.95 kg/cm^2. An attempt was made to determine a rate of recovery from compaction by dividing recognizable tank tracks into "new" (no vegetation) and "old" (vegetation beginning to recover). The mean penetrometer reading on "new" tracks was 3.51 kg/cm^2, and on "old" tracks, 2.80 kg/cm^2. However, the variance is quite high, and the difference is not statistically significant. Transect information gave results of 6 percent disturbance (SSDI) for the control and 74 percent SSDI for the test site.

Birds

An ecological baseline study of Fort Hood reported 88 bird species observed during the fall survey, and an additional 47 during the spring.[14] Of the 135 species, 44 were observed on the two tactical vehicle study sites, with 28 on the test site and 31 on the control site

---

[14]W. D. Severinghaus, R. S. Baran, and R. E. Riggins, *Ecological Baseline—Fort Hood, Texas*, Technical Report N-95/ADA088271 (CERL, August 1980).

Table 5

Avian Species; Densities and Biomass

	Test		Control		
	No./100 ha	g/100ha	No./100 ha	g/100 ha	Guild
Test and Control					
Turkey vulture	0.24	528.0	2.71	5962.0	16
Bobwhite	1.59	294.2	2.50	462.5	8
Mourning Dove	4.44	577.2	13.75	1787.5	8
Yellow-billed cuckoo	1.90	114.0	1.67	100.2	14
Carolina chickadee	6.35	57.2	31.11	280.0	5
Tufted titmouse	24.45	513.5	77.36	1624.6	5
Carolina wren	3.17	6.34	6.25	125.0	15
White-eyed vireo	17.78	231.1	11.25	146.3	14
Nashville warbler	8.57	68.6	10.00	80.0	13
Black-throated green warbler	1.27	11.4	16.67	150.0	13
Eastern meadowlark	6.35	698.5	10.28	1130.8	28
Brown-headed cowbird	57.78	2600.1	47.78	2150.1	30
Summer tanager	2.22	73.3	23.33	769.9	2
Cardinal	51.43	2057.2	110.00	4400.0	3
Rufuous-sided towhee	13.33	573.2	4.17	179.3	3
Test Only					
Turkey	0.38	2850.0			7
Killdeer	0.95	85.5			24
Eastern kingbird	5.71	205.6			12
Great crested flycatcher	1.90	68.4			13
House wren	1.27	15.2			15
Bewick's wren	3.65	25.6			15
Mockingbird	28.57	1428.5			31
Painted bunting	19.05	285.8			1
Lark sparrow	44.13	1235.6			1
Rufous-crowned sparrow	7.14	149.9			3
Chipping sparrow	2.54	33.0			1
White-crowned sparrow	6.35	190.5			1
Song sparrow	0.95	20.0			3
Control Only					
Black vulture			0.42	1008.0	16
Mississippi kite			0.83	232.4	21
Great horned owl			11.25	15 750.0*	18
Chimney swift			2.08	43.7	11
Ruby-throated hummingbird			24.17	749.3	6
Dendrocopos sp.			1.67	45.1	26
Barn swallow			8.33	174.9	11
Purple martin	2.22	99.9	11		
White-breasted nuthatch		4.17	87.6	15	
Swainson's thrush			16.95	559.4	27
Blue-gray gnatcatcher			8.33	50.0	15
Ruby-crowned kinglet			20.83	125.0	15
Cedar waxwing			8.33	249.9	2
Yellow-rumped warbler			6.25	43.8	13
Common grackle			0.56	94.1	28
White-throated sparrow			23.33	653.2	3
Totals			15 054.5	23 564.7	

*Data not included in total because of its unusual nature (bird was immature, nesting close to transect).

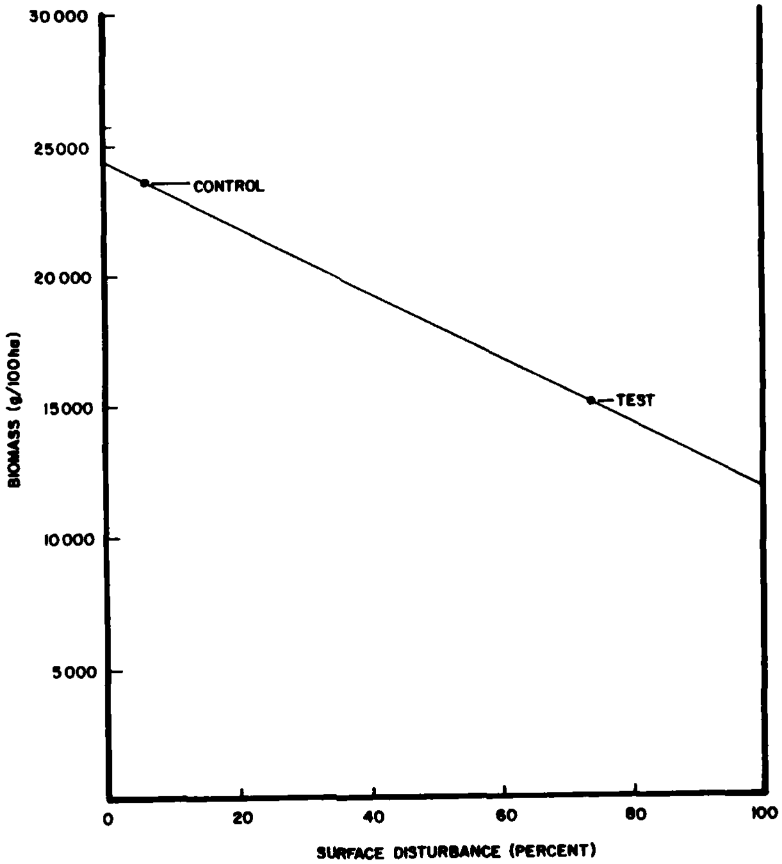


Figure 3. Bird biomass versus percent disturbance.

(Table 5). The data were analyzed by examining total biomass and diversity, and by using guild theory.[15]

Because it eliminates variation between habitat types and concentrates on the amount of sustainable life present, total biomass is the most effective measure of the overall impact tracked vehicle training has on bird populations. Biomass was totaled for both the test site (15 045.5 g/100 ha) and the control site (23 564.7 g/100 ha). The biomass data were then graphed (Figure 3) against the amount of soil surface disturbance previously analyzed. If one assumes that change in biomass per amount of disturbance is a linear relationship, this graph can be used to estimate the amount of avian biomass at sites having 0 to 100 percent surface disturbance (Table 6). The percentage lost (38 percent) fell well within the ranges of 20.9 percent for a short-term use site (less than 1 year) and 59.8 percent for a long-term use site (over 45 years) at Fort Knox, KY.[16]

The change in diversity between the two sites was expected, with 15 species being found on both test and control, 13 species only on the test, and 16 species only on the control. Of the 15 species occupying both test and control, the four showing a preference for the test area were the yellow-billed cuckoo, white-eyed vireo, brown-headed cowbird, and rufous-sided towhee; the latter three are wood margin, hedge row, and open country dwellers. The rufous-sided towhee showed a significant preference for the test site ($0.05 > p > 0.025$, Table 7). The remaining 11 species common to both test and control showed a preference for the control, with six species showing a significant preference for the control (mourning dove, $0.05 > p > 0.025$; carolina chickadee, $p < 0.005$; tufted titmouse, $p < 0.005$; black-throated green warbler, $p < 0.005$;

[15] W. D. Severinghaus, R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds, and Vegetation at Fort Knox, KY*, Special Report N-77/ADA073782 (CERL, July 1979); W. D. Severinghaus, "Guild Theory Development as a Mechanism for Assessing Environmental Impact," *Journal of Environmental Management*, Vol. 5, No. 3 (1981), pp 187-190.

[16] W. D. Severinghaus, R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds, and Vegetation at Fort Knox, KY*, Special Report N-77 ADA073782 (CERL, July 1979).

Table 6

Change in Biomass Because of Training

Percent Soil Surface Disturbance	Total Bird Biomass, g/100 ha	Percent Change
0*	24 300*	0*
6	23 560	−3
74	15 050	−38
100*	11 750*	−52*

*Projected from Figure 3.

summer tanager, $p < 0.005$; cardinal, $p < 0.005$). Of these six species only one, the mourning dove, is not a forest or woodland dweller, but it does nest in trees.

CERL also analyzed the diversity of species present only on the test or the control. Almost all of the 13 species seen only on the test (Table 5) were open woodland, field, shrub, fencerow, thicket, or woodland margin dwellers. The only exception was the great crested flycatcher. Of the species found only on the test, three were present in significant numbers (mockingbird, $p < 0.005$; painted bunting, $p < 0.005$; lark sparrow, $p < 0.005$). The 16 species observed only on the control were virtually all woodland and forest dwellers—except the black vulture, Mississippi kite, barn swallow, common grackle, and the rather secretive ruby-throated hummingbird and white-throated sparrow. The major finding of this bird study was that 14 species showed a significant ($p < 0.05$) preference for the control (Table 7).

Table 7

Significant Site Preference

Test Site Preference:	
*Rufous-sided towhee	$0.05 > p > 0.025$
Mockingbird	$p < 0.005$
Painted bunting	$p < 0.005$
Lark sparrow	$p < 0.005$
Control Site Preference:	
*Mourning dove	$0.05 > p > 0.025$
*Carolina chickadee	$p < 0.005$
*Tufted titmouse	$p < 0.005$
*Black-throated green warbler	$p < 0.005$
*Summer tanager	$p < 0.005$
*Cardinal	$p < 0.005$
Green horned owl	$0.025 > p > 0.01$
Ruby-throated hummingbird	$p < 0.005$
Barn swallow	$0.05 > p > 0.025$
Swainson's thrush	$p < 0.005$
Blue-gray gnatcatcher	$0.05 > p > 0.025$
Ruby-crowned kinglet	$p < 0.005$
Cedar waxwing	$0.05 > p > 0.025$
White-throated sparrow	$p < 0.005$

*Found on both test and control sites.

At Fort Hood, CERL applied guild theory, which maintains that species belonging to the same guild use resources similarly. When this theory is used to analyze environmental change, two products should result: (1) as negative or positive changes in each species are combined with those in other species of the same guild, the cause of the changes should become more evident; and (2) as the causal relationships are determined and the quantity of basic data increases guild by guild, the cause and effect relationships between man and his environment should become more predictable.

The bird data from Fort Hood were tabulated according to the guild scheme in Table 8.[17] The important points to note are the guild characteristics, the direction of change (positive or negative), and the probable cause of the change. Of the 21 guilds on which data were gathered, three (numbers 16, 18, and 21) had such small sample sizes—or other biases—that their accuracy is questionable. Only one individual of guilds 16 (a black vulture) and 21 (a Mississippi kite) was observed. The single member of guild 18 was an immature, but fledged, great horned owl which was staying on the original nest within 20 m of the transects. It was observed every day, and made no attempt to leave its perch when approached.

For the bird population in general, the data collected indicate that positive or negative changes were caused by one major habitat disturbance: the opening of the woodlands and the understory. Secondary effects were the change in the availability of food sources (guilds 11, 26, and 28) or the change caused by species' tolerance of disturbance (guilds 6 and 31).

Mammals

Only four species were captured from small mammal trapping at the control and test sites, and only two of these species were found at the control site (Table 9). In trapping during the spring of 1979 at seven other sites on Fort Hood, two different species were captured: the pygmy mouse, *Baiomys taylori*, and the plains harvest mouse, *Reithrodontomys montanus*. The two *Peromyscus* species found at the test and control sites were also the most abundant at these seven sites. In trapping near the same sites during the autumn of 1978, four other species were found—the deer mouse, *Peromyscus maniculatus*;

[17] W. D. Severinghaus, "Guild Theory Development as a Mechanism for Assessing Environmental Impact," *Journal of Environmental Management*, Vol. 5, No. 3 (1981), pp 187-190.

Table 8

Tracked Vehicle Effects on Bird Guilds

Primary Guild Characteristic	Biomass Test	Biomass Control	Percent Change	Probable Cause
1. Seedeating, open field	1744.9	--	+100.0	Opens woodlands, open field species invade
2. Seedeating, woodland	73.3	1019.8	-92.8	Opens woodlands
3. Seedeating, edge	2800.3	5232.5	-46.5	
5. Fruit seed, woods edge	570.7	1904.6	-70.0	Opens woodlands
6. Nectar	--	749.3	100.0	Probably relates to species sensitivity secretiveness
7. Mast grain, woodland open understory	2850.0	--	+100.0	Opens woodlands and understory
8. Mast grain, small, brush field	871.4	2250.0	-61.3	Reduces understory
11. Insectivorous, sustained, diurnal	--	318.5	-100.0	Reduction in suitable habitat for food source
12. Insectivorous, sallying, open	205.6	--	+100.0	Opens woodland
13. Insectivorous, sallying, woodland	148.4	303.8	-51.2	Opens woodland
14. Insectivorous, gleaner, large	345.1	246.1	+28.6	Opens woodland and understory
15. Insectivorous, gleaner, small	104.2	287.6	-73.1	Opens woodlands and understory
16. Carnivorous, carrion	528.0	6970.0	-92.4	Probable reduced food source
18. Carnivorous, hunter, night, large	--	15 750.0	-100.0	Information accuracy questionable because of sample size
21. Carnivorous, hunter	--	232.4	100.0	Sample size too low to allow accuracy
24. Invertebrate, pasture field	85.5	--	+100.0	Opens woodlands
26. Invertebrate, woodworker	--	45.1	-100.0	Reduction of feeding habitat by loss of trees
27. Omnivorous, woods brush	--	559.4	-100.0	Opens woodlands and reduces understory
28. Omnivorous, open field	698.5	1224.9	-43.0	Reduction in food sources
30. Omnivorous, mixed, non-ground	2600.1	2150.1	+17.3	Opens woodlands
31. Omnivorous, disturbed sites	1428.5	--	+100.0	Sites were disturbed

Table 9

Mammal Capture Data

Species (Scientific Names)	Captives Control	Captives Test	Captive Index Control	Captive Index Test	Population Change, Percent; Control/Test	Chi-square Test of Distribution
Sylvilagus floridanus	0	1				
Perognathus flavus	0	5	0.00	2.45	+100%	0.025 to 0.05*
Peromyscus pectoralis	12	13	6.44	6.38	−1%	> 0.995
Peromyscus attwateri	20	29	10.73	14.23	+33%	0.1 to 0.5

*Statistically different at the p = 0.05 level.

the hispid cotton rat, *Sigmodon hispidus*; the eastern wood rat, *Neotoma floridana;* and the fulvous harvest mouse, *Reithrodontomys fulvescens.*[18]

The capture index values, the percent change in populations from control to test, and the results of the chi-square test are given in Table 9 for three of the four species found on the control and test sites. The eastern cottontail, an immature, was captured on the test site; it can be reasonably assumed that this species also inhabits the control site. Data for the species were insufficient for comparison and analysis.

From the results, it is evident that the number of small mammals captured on the test site exceeded the number captured on the control site for each of the three comparable species. However, the number of trap nights was larger on the test site (2038) than on the control site (1864); this factor tended to equalize the results. The chi-square test of distributions indicated a significant difference in the number of silky pocket mice ($p < 0.05$), but there was essentially no difference in the populations of white-ankled mice, *Peromyscus pectoralis*, and only a weak statistical difference in the populations of brush mice, *Peromyscus attwateri*, captured on the two sites.

The silky pocket mouse, *Perognathus flavus*, was found only on the test site. This species typically occurs in the more xeric regions of south and west Texas, and at Fort Hood is at the eastern extreme of its range. Schmidly reports that "tall, dense ground cover restricts its [the silky pocket mouse's] move-

[18] W. D. Severinghaus, R. S. Baran, and R. E. Riggins, *Ecological Baseline, Fort Hood, Texas*, Technical Report N-95 ADA088271 (CERL, August 1980), p 85.

ments, whereas short ground cover does not."[19] Five individuals of this species were captured, all from open sparsely vegetated, or completely devegetated areas subject to repeated military vehicle traffic.

The diet of this mouse consists mainly of seeds.[20] While there were more high-seed-producing weedy annuals at the test site than at the control site, the presence of this species only at the test site appears to be closely related to the change of habitat resulting from intensive military activities.

Two species of the genus *Peromyscus*, the white-footed mice, were found on both the control and test sites. These are the white-ankled or encinal mouse, *Peromyscus pectoralis*, and *Peromyscus attwateri*, which was formerly considered a sub-species of the brush mouse, *Peromyscus boylei*.

The white-ankled mouse's range extends through the tableland of northern Mexico north into southern Arizona and central Texas. This species is associated with rocky areas and oak-juniper woodlands; juniper berries, acorns, and hackberries compose much of its diet.[21] Species of oak and juniper dominated the overstory at test and control sites, and netleaf hackberry was also found on both sites. Captures of the white-ankled mouse were essentially equal on the two sites.

Peromyscus attwateri ranges from western and north central Texas into Oklahoma, Arkansas, and southwestern Missouri. Like *P. pectoralis*, this mouse prefers rocky habitats with areas of brush and trees, but can also be found along stream banks, rock walls, and talus slopes; occasionally it enters cabins.[22] It is frequently found with the white-ankled mouse.[23] Studying populations of several species of *Peromyscus* in southwestern Missouri, Brown found that the diet of *P. attwateri* was 50 to 60 percent seeds, 25 to 35 percent insects, and up to 15 percent berries during the early spring months.[24] Davis reports that in Texas brush and woodlands, acorns are a favorite food, as are hackberries, juniper berries, and cactus fruits. Davis also describes these mice as adept at climbing and states that "without doubt they garner much of their food in trees."[25]

[19]David J. Schmidly, *The Mammals of Trans-Pecos Texas* (Texas A&M University Press, 1977), p 81.

[20]Schmidly, p 83.

[21]William B. Davis, *The Mammals of Texas*, Bulletin No. 41 (Texas Game and Fish Commission, 1960), p 185.

[22]Davis, p 183.

[23]Schmidly, p 110; and Davis, p 185.

[24]L. N. Brown, "Ecology of Three Species of Peromyscus from Southern Missouri," *Journal of Mammalogy*, Vol. 45 (1964), p 198.

[25]Davis, p 184.

Peromyscus attwateri, the most frequently captured species, was taken about 33 percent more often on the test site than on the control. However, both *P. attwateri* and *P. pectoralis* were more or less uniformly dispersed throughout the control site, while almost all of the *Peromyscus* captured from the test site were found within or along the edge of the relatively undisturbed islands of vegetation.

Biomass was also used as a means of comparing captives from the two sites. Figure 4 graphs variations in the biomass of each of the three compared species captured from the test and control sites, and the totals of these three species. The biomass for the test site increased 23 percent over that for the control, with *P. attwateri* accounting for most of this weight increase.

In a similar study at Fort Knox, an analysis of small mammal biomass by guilds was also useful.[26] At Fort Knox, data were obtained for small mammal species from four of the 30 guilds; while at Fort Hood, data were collected for species from only two guilds—11, the seed eating, secretive, burrow dwellers (pocket mice, kangaroo rats), and 12, the seed eating, secretive, nest dwellers (white-footed mice, harvest mice, and jumping mice). Further, species from only one of these guilds, 12, were found on the control site. The results, a biomass comparison by guild for control and test sites, are given in Table 10. For both guilds, biomass was greater on test than on control.

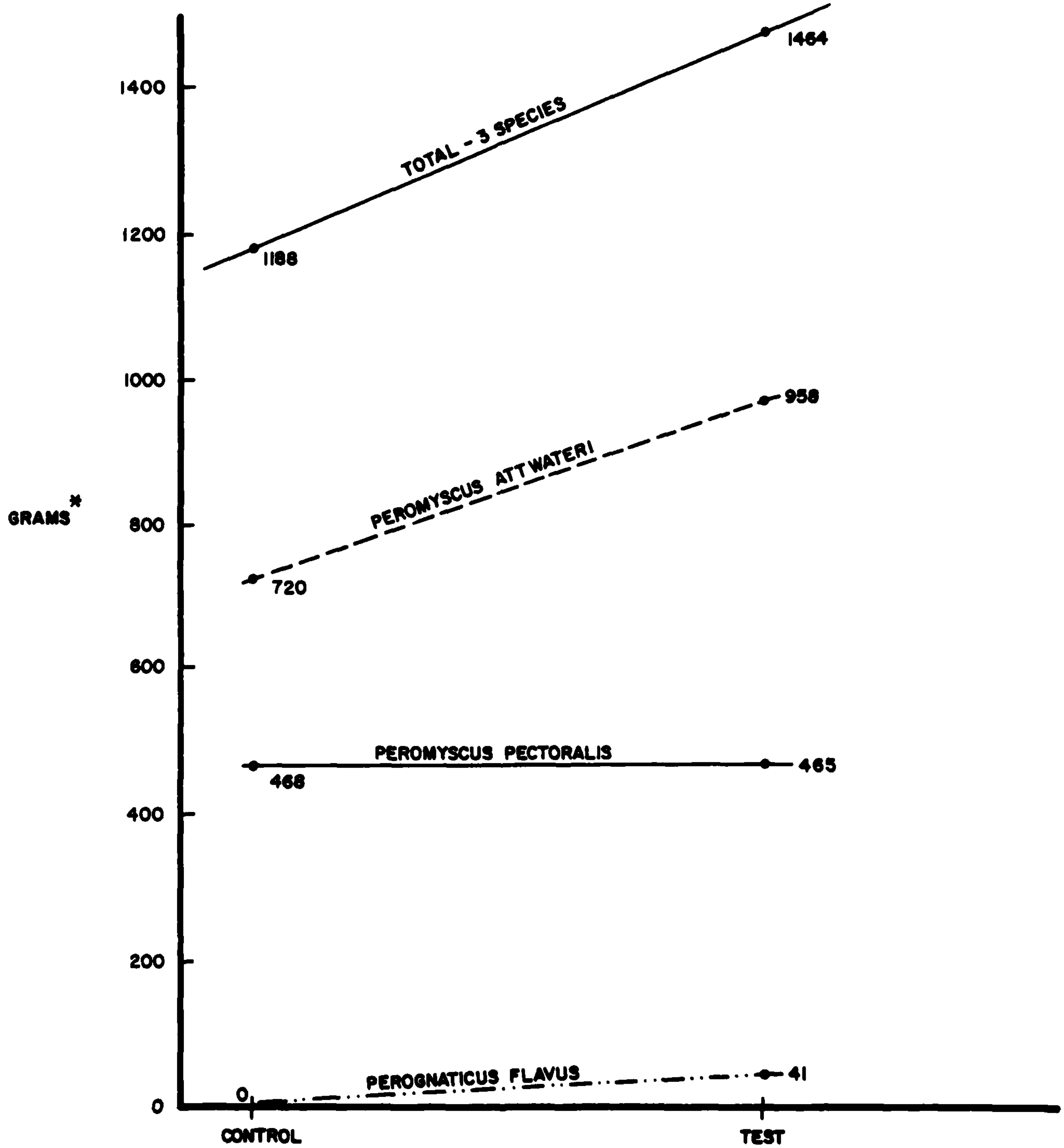
Table 10

Guild Biomass

Guild		Biomass Control (in grams)	Test	Change
11.	Pocket mice, kangaroo rats	0	41	100 percent
12.	White-footed mice	1188	1423	20 percent
	Totals	1188	1464	23 percent

While predictions from the 1979 Fort Knox report for guild 12 (white-footed mice) were reinforced by the Fort Hood results, predictions for guild 11 (pocket mice and kangaroo rats) conflicted with the results obtained at Fort Hood. No members of guild 11 were encountered at Fort Knox. But from results observed in other guilds, it was predicted that for both short and long-term situations, the probable

[26]W. D. Severinghaus, R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds and Vegetation at Fort Knox, KY*, Special Report N-77/ADA073782 (CERL, July 1979), p 48.



*Biomass (adjusted for trap nights) based on the highest weight range values from W. B. Davis, *The Mammals of Texas,* Bulletin No. 41 (Texas Game and Fish Commission, 1960).

Figure 4. Biomass for small mammals.

impact on the den-nest-cover parameter would be negative and extensive, and for the food parameter, negative but minimal.[27] The silky pocket mouse was the only guild 11 species captured at Fort Hood, and it was found only on the test grid in the areas exposed to the long-term impacts of tracked vehicle training.

Like the white-footed mouse, the seed-eating pocket mouse benefits from the increased seed production of the weedy annuals that characterize disturbed sites, but more importantly, this mouse benefits from the change in habitat resulting from repeated mechanical disturbance of vegetation and soils. Through vehicle activity, the relatively dense and mesic ground cover of the Cross Timbers and Prairie Vegetational Area has been replaced by a more sparse and xeric micro-environment favorable to the pocket mice. The Fort Hood results indicate that the impact of tracked vehicle activity on guild 11 is also positive.

At Fort Knox, captures of white-footed mice increased on undisturbed sites. It was thought this happened in part because reproductive males wandered more, increasing their home range size to survive on areas of reduced vegetation. Small mammals were captured at Fort Knox with live traps set in rectangular grids at a forested site (control); a site characterized by brush piled in gulleys, with only widely spaced, mature trees left standing (short-term); and an intensively used barrier site with deep erosion gulleys (long-term). No white-footed mice were captured in live traps at the control site (which did support shrews, voles, and chipmunks), but white-footed mice dominated the short- and long-term sites, with males composing 80 percent of the individuals of this species captured on the short-term site and 77.8 percent on the long-term site. Also, toward the end of the trapping period (20 days in April and May) there was an increase in the number of scrotal males among the captured *Peromyscus.*

At Fort Hood, however, a similar male/female sex ratio in captured individuals of *Peromyscus pectoralis* and *peromyscus attwateri* was not observed. Here, proportions of males to females were essentially even on both control (48.5 percent male, 51.5 percent female) and test (47.2 percent male, 52.8 percent female). Also, few scrotal males were on either control or test.

[27]Severinghaus, Riggins, and Goran, pp 17 and 49; John A. King, ed., *Biology of Peromyscus (Rodentia),* Special Publication No. 2 (The American Society of Mammalogists, 1968), p 114.

5 DISCUSSION

Vegetation and Soil

Training activities on the test area at Fort Hood have damaged the vegetation and soil considerably. A reasonable estimate is that intensive tracked vehicle activity on any particular site for a number of years in the Fort Hood area will reduce total plant cover by about 60 percent and will disturb about 60 percent of the surface soil. This estimate is based on the fact that the test area has 41 percent as much plant cover as the control area. For woody plants, the principal effect of training activities seems to be a simple reduction of density and cover without any major shifts in species composition. With herbaceous plants, however, there was a major shift in species composition from relatively large perennial plants to small annuals. These plants have an advantage under disturbed conditions because they complete their life cycle within a few months, and thus have a better chance of reproducing before being destroyed.

Continued training activities at the current level on the same site probably will not cause much further deterioration. Travel along the trail network seems to have stabilized, with only a few new trails having been formed in the past few years. There has been some recent, but minor, damage to woody vegetation.

Furthermore, soil damage will probably be minimal because existing soil is thin and gravelly, even on completely undisturbed sites. The bedrock is very close to the surface, thereby preventing the formation of deep gullies. After the thin layer of topsoil washes away soon after the establishment of a vehicle trail, there is very little material left to erode.

Birds

In areas where the most training is done, there has been approximately a 40 percent loss of bird biomass. Generally, this conforms to results obtained in other ecological systems. Though the number of species stayed nearly the same—28 in the test area and 31 in the control—the diversity changed. The two areas had only 15 species in common. Training caused a reduction or loss of the sensitive, pure woodland species and a gain in edge, less sensitive, and disturbed-site species.

Additional changes in bird species should not be expected unless Fort Hood begins to use the training areas more, or opens new areas. The major problem would be the continued loss of some of the more sensitive and habitat-restricted species, whose existence in the general area would be threatened.

Mammals

More animals were captured at the test site than at the control. In addition, the animals' total amount of biomass increased at the test area. However, the populations of the individual species captured from the two sites were significantly different at the 0.05 level only for the silky pocket mouse. And this species, which is quite small (from 7 to 9 g), composed less than 30 percent of the total biomass from the test site. The mammal captures from the test and control sites were not significantly different; the small mammal species found in the juniper-oak woodlands of Fort Hood apparently are able to tolerate the effects of vehicle training activities, despite extensive alteration of habitat and significant loss of vegetative cover. The adaptability of these species relates both to their particular habits and to the pattern of military land use.

On woodland training sites at Fort Hood, vehicle traffic produces wide corridors which are travelled frequently, and vegetated "islands" through which vehicles seldom pass. While 60 to 70 percent of the ground surface on the test site was disturbed often, the undamaged islands on the remaining 30 to 40 percent were sufficiently large, and near enough to one another, to provide refugia for a number of small mammals equal to or greater than the population on undisturbed areas. This pattern of training land use in the juniper-oak woodlands occurred widely at Fort Hood and had been established over many years of intensive off-road traffic. When visited 18 months after the study, this test site was in essentially the same condition, with only minor evidence of increased damage to the 30 to 40 percent vegetative cover. All the small mammals, except *Perognathus flavus*, were found on these vegetated islands. Further loss of vegetation and habitat disruption may result in population declines.

From results of the 1978 Fort Knox study, it was predicted that the impacts of extensive tracked vehicle activity at Fort Hood would have a "positive and moderate" effect on the den-nest-cover parameter and a "negative but minimal" effect on the food parameter for mammals of guild 12—the seed eater, secretive, nest-dwelling guild to which species of the genus *Peromyscus* belong. Both the pattern of impact and the terrestrial environment at Fort Knox were significantly different from Fort Hood. Yet at sites affected by training on both installations, there was an overall increase of mammals of the genus *Peromyscus*. (At Fort Knox, these mammals were from the species *Peromyscus leucopus*.) In *Biology of Peromyscus*, King writes, "It is likely that such species as *P. boylei, P. californicus, P. leucopus, P. maniculatus, P. melanophrys*, and *P. pectoralis* have been considerably favored by man's operations. Since the coming of European man, land-use practices (grazing by domestic livestock, lumbering, suppression of fires, clearing and cultivation) have increased the amount of brushlands."[28] Off-road tracked vehicle training activities disturb both mature woodlands and grasslands, resulting in various mixed "brushlands" with annual forbs as a predominant herb cover. These disturbed environments are apparently suitable for several species of the genus *Peromyscus*, with the annual forbs producing abundant seed crops supplementing tree and brush mast, and the trees and brush meeting den-nest-cover needs. According to King, "Except for grassland areas, swamps, and deserts, where other rodents may be dominant, species of *Peromyscus* usually are the most common mammals present."[29]

In the undisturbed juniper-oak woodlands at Fort Hood, there were natural canopy openings and many understory trees; the herbaceous stratum was dominated by perennial grasses and sedges. On the test site, there was a significant decrease in the aerial coverage of tree, woody understory, and herbaceous plants; a significant increase in the overall number of herbaceous plants; and a shift from grasses and sedges to weedy annuals. This shift caused increased seed production, and may be a factor in the capacity of the impacted woodlands to sustain small mammal populations.

The two *Peromyscus* species, *attwateri* and *pectoralis*, were the only small mammals found in these undisturbed woodlands. There was no evidence that training activities adversely affected these animals: they tolerate human disturbances, the pattern of vehicle activity results in undisturbed refuges, and food supplies are readily available.

6 CONCLUSIONS

1. This report has described preliminary indications of ecological differences between selected Army tracked vehicle training areas and areas undisturbed by training. This study indicated that there is about a 40 percent loss in vegetation. In areas of shallow soils, once the vegetation is lost, erosion removes the topsoil and soon ceases to be a major problem since bedrock is quickly reached. Bird populations also suffered a 40 percent loss in biomass with an accom-

---

[28] John A. King, ed., *Biology of Peromyscus (Rodentia)*, Special Publication No. 2 (The American Society of Mammalogists, 1968), p 114.

[29] King, p 114.

panying change in diversity. Small mammal populations showed no change in biomass, but the number of rodents preferring an open desert habitat did increase.

2. The procedures used to obtain the field data and analyze this information proved efficient and effective.

3. This report has analyzed Fort Hood's ecosystem to verify tactical vehicle cause-effect relationships examined in other ecosystems. The results from this live oak-juniper scrubland were generally comparable to information obtained previously.

REFERENCES

Amadon, D., "Bird Weights and Egg Weights," *Auk,* Vol. 60 (1943), pp 221-234.

Baldwin, S. R. and S. C. Kendeigh, "Variation in the Weight of Birds," *Auk,* Vol. 55 (1938), pp 416-467.

Balph, M. H., L. C. Stoddart, and D. F. Balph, "A Simple Technique for Analyzing Bird Transect Counts," *Auk,* Vol. 94 (1977), pp 606-607.

Behle, W. N., "Weights of Some Western Species of Horned Larks," *Auk,* Vol. 60 (1943), pp 216-221.

Brown, L. N., "Ecology of Three Species of Peromyscus from Southern Missouri," *Journal of Mammalogy,* Vol. 45 (1964), p. 198.

Bruce, D., "A New Way to Look at Trees," *Journal of Forestry,* Vol. 53 (1955), pp 163-167.

Cox, G. W., *Laboratory Manual of General Ecology* (W. C. Brown Co., 1967).

Davis, William B., *The Mammals of Texas,* Bulletin No. 41 (Texas Game and Fish Commission, 1960).

Emlen, J. T., "Estimating Breeding Bird Densities from Transect Counts," *Auk,* Vol. 94 (1977), pp 455-468.

Emlen, J. T., "Population Densities of Birds Derived from Transect Counts," *Auk,* Vol. 88 (1971), pp 323-342.

Esten, S. R., "Bird Weights of 52 Species of Birds (Taken from Notes of William Van Goider)," *Auk,* Vol. 48 (1931), pp 572-574.

Gould, F. W., *Texas Plants—A Checklist and Ecological Summary* (Texas A&M University, Texas Agricultural Experiment Station, MP-585/REV., 1975).

Graber, R. R. and J. W. Graber, "Weight Characteristics of Birds Killed in Nocturnal Migration," *Wilson Bulletin,* Vol. 74, No. 1 (1962), pp 74-88.

Johnson, F. L. and D. T. Bell, "Size—Class Structure of Three Streamside Forests," *American Journal Botany,* Vol. 62 (1975), pp 81-83.

Johnson, F. L. and P. G. Risser "A Quantative Comparison Between an Oak Forest and an Oak Savannah in Central Oklahoma," *Southwest Naturalist,* Vol. 20 (1975), pp 75-84.

King, John A., ed., *Biology of Peromyscus (Rodentia),* Special Publication No. 2 (The American Society of Mammalogists, 1968).

Norris, R. A. and D. W. Johnson, "Weights and Weight Variations in Summer Birds from Georgia and South Carolina," *Wilson Bulletin,* Vol. 70, No. 2 (1958), pp 114-129.

Oberholser, H. C., *The Bird Life of Texas,* 2 Vols. (University of Texas Press, 1974).

Poole, E. L., "Weights and Wing Areas in North American Birds," *Auk,* Vol. 55 (1938), pp 513-518.

Rice, E. L. and W. T. Penfound, "An Evaluation of the Variable-Radius and Paired-Tree Methods in the Blackjack-Post Oak Forest," *Ecology,* Vol. 36 (1955), pp 315-320.

Schmidly, David J., *The Mammals of Trans-Pecos Texas* (Texas A&M University Press, 1977).

Severinghaus, W. D., *Guidelines for Terrestrial Ecosystem Survey,* Technical Report N-89/ADA086526 (U.S. Army Construction Engineering Research Laboratory [CERL], May 1980).

Severinghaus, W. D., "Guild Theory Development as a Mechanism for Assessing Environmental Impact," *Journal of Environmental Management,* Vol. 5, No. 3 (1981), pp 187-190.

Severinghaus, W. D., R. S. Baran, and R. E. Riggins, *Ecological Baseline, Fort Hood, Texas,* Technical Report N-95/ADA088271 (CERL, August 1980).

Severinghaus, W. D., R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds, and Vegetation at Fort Knox, KY,* Special Report N-77/ADA073782 (CERL, July 1979).

Stokes, M. A. and T. L. Smiley, *An Introduction to Tree-Ring Dating* (University of Chicago Press, 1968).

CERL DISTRIBUTION

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-ASI-L (2)
ATTN: DAEN-CCP
ATTN: DAEN-CW
ATTN: DAEN-CWE
ATTN: DAEN-CWM-R
ATTN: DAEN-CWO
ATTN: DAEN-CWP
ATTN: DAEN-MP
ATTN: DAEN-MPC
ATTN: DAEN-MPE
ATTN: DAEN-MPO
ATTN: DAEN-MPR-A
ATTN: DAEN-RD
ATTN: DAEN-RDC
ATTN: DAEN-RDM
ATTN: DAEN-RM
ATTN: DAEN-ZC
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM

US Army Engineer Districts
ATTN: Library
Alaska
Al Batin
Albuquerque
Baltimore
Buffalo
Charleston
Chicago
Detroit
Far East
Fort Worth
Galveston
Huntington
Jacksonville
Japan
Kansas City
Little Rock
Los Angeles
Louisville
Memphis
Mobile
Nashville
New Orleans
New York
Norfolk
Omaha
Philadelphia
Pittsburgh
Portland
Riyadh
Rock Island
Sacramento
San Francisco
Savannah
Seattle
St. Louis
St. Paul
Tulsa
Vicksburg
Walla Walla
Wilmington

US Army Engineer Divisions
ATTN: Library
Europe
Huntsville
Lower Mississippi Valley
Middle East
Middle East (Rear)
Missouri River
New England
North Atlantic
North Central
North Pacific
Ohio River
Pacific Ocean
South Atlantic
South Pacific
Southwestern

Waterways Experiment Station
ATTN: Library

Cold Regions Research Engineering Lab
ATTN: Library

US Government Printing Office
Receiving Section/Depository Copies (2)

Defense Technical Information Center
ATTN: DDA (12)

Engineering Societies Library
New York, NY

FESA, ATTN: Library

ETL, ATTN: Library

Engr. Studies Center, ATTN: Library

Inst. for Water Res., ATTN: Library

SHAPE
ATTN: Survivability Section, CCB-OPS
Infrastructure Branch, LANDA

HQ USEUCOM
ATTN: ECJ 4/7-LOE

Army Instl. and Major Activities (CONUS)
DARCOM - Dir., Inst., & Svcs.
ATTN: Facilities Engineer
ARRADCOM
Aberdeen Proving Ground
Army Matls. and Mechanics Res. Ctr.
Corpus Christi Army Depot
Harry Diamond Laboratories
Dugway Proving Ground
Jefferson Proving Ground
Fort Monmouth
Letterkenny Army Depot
Natick Research and Dev. Ctr.
New Cumberland Army Depot
Pueblo Army Depot
Red River Army Depot
Redstone Arsenal
Rock Island Arsenal
Savanna Army Depot
Sharpe Army Depot
Seneca Army Depot
Tobyhanna Army Depot
Tooele Army Depot
Watervliet Arsenal
Yuma Proving Ground
White Sands Missile Range

FORSCOM
FORSCOM Engineer, ATTN: AFEN-FE
ATTN: Facilities Engineers
Fort Buchanan
Fort Bragg
Fort Campbell
Fort Carson
Fort Devens
Fort Drum
Fort Hood
Fort Indiantown Gap
Fort Irwin
Fort Sam Houston
Fort Lewis
Fort McCoy
Fort McPherson
Fort George G. Meade
Fort Ord
Fort Polk
Fort Richardson
Fort Riley
Presidio of San Francisco
Fort Sheridan
Fort Stewart
Fort Wainwright
Vancouver Bks.

TRADOC
HQ, TRADOC, ATTN: ATEN-FE
ATTN: Facilities Engineer
Fort Belvoir
Fort Benning
Fort Bliss
Carlisle Barracks
Fort Chaffee
Fort Dix
Fort Eustis
Fort Gordon
Fort Hamilton
Fort Benjamin Harrison
Fort Jackson
Fort Knox
Fort Leavenworth
Fort Lee
Fort McClellan
Fort Monroe
Fort Rucker
Fort Sill
Fort Leonard Wood

INSCOM - Ch, Instl. Div.
ATTN: Facilities Engineer
Vint Hill Farms Station
Arlington Hall Station

WESTCOM
ATTN: Facilities Engineer
Fort Shafter

MDW
ATTN: Facilities Engineer
Cameron Station
Fort Lesley J. McNair
Fort Myer

HSC
HQ USAHSC, ATTN: HSLO-F
ATTN: Facilities Engineer
Fitzsimons Army Medical Center
Walter Reed Army Medical Center

USACC
ATTN: Facilities Engineer
Fort Huachuca
Fort Ritchie

MTMC
HQ, ATTN: MTMC-SA
ATTN: Facilities Engineer
Oakland Army Base
Bayonne MOT
Sunny Point MOT

US Military Academy
ATTN: Facilities Engineer
ATTN: Dept of Geography & Computer Science
ATTN: DSCPER/MAEN-A

USAES, Fort Belvoir, VA
ATTN: ATZA-DTE-EM
ATTN: ATZA-DTE-SW
ATTN: ATZA-FE
ATTN: Engr. Library

Chief Inst. Div., I&SA, Rock Island, IL

USA ARRCOM, ATTN: Dir., Instl & Svc
TARCOM, Fac. Div.
TECOM, ATTN: DRSTE-LG-F
TSARCOM, ATTN: STSAS-F
NARAD COM, ATTN: DRDNA-F
AMMRC, ATTN: DRXMR-WE

HQ, XVIII Airborne Corps and Ft. Bragg
ATTN: AFZA-FE-EE

HQ, 7th Army Training Command
ATTN: AETTG-DEH (5)

HQ USAREUR and 7th Army
ODCS/Engineer
ATTN: AEAEN-EH (4)

V Corps
ATTN: AETVDEH (5)

VII Corps
ATTN: AETSDEH (5)

21st Support Command
ATTN: AEREH (5)

US Army Berlin
ATTN: AEBA-EN (2)

US Army Southern European Task Force
ATTN: AESE-ENG (5)

US Army Installation Support Activity, Europe
ATTN: AEUES-RP

8th USA, Korea
ATTN: EAFE
Cdr, Fac Engr Act (8)
AFE, Yongsan Area
AFE, 2D Inf Div
AFE, Area II Spt Det
AFE, Cp Humphreys
AFE, Pusan
AFE, Taegu

DLA ATTN: DLA-WI

USA Japan (USARJ)
Ch, FE Div, AJEN-FE
Fac Engr (Honshu)
Fac Engr (Okinawa)

ROK/US Combined Forces Command
ATTN: EUSA-HHC-CFC/Engr

416th Engineer Command
ATTN: Facilities Engineering

Norton AFB
ATTN: AFRCE-MX/DEE

Port Hueneme, CA 93043
ATTN: Library (Code L08A)

AFESC/Engineering & Service Lab
Tyndall AFB, FL 32403

Chanute AFB, IL 61868
3345 CES/DE, Stop 27

National Guard Bureau
Installation Division
WASH DC 20310

ENS Team Distribution

USA ARRADCOM
ATTN: DRDAR-LCA-OK

Ft. Clayton, Canal Zone 34004
ATTN: DFAE

West Point, NY 10996
ATTN: Dept of Mechanics
ATTN: Library

HQDA (SGRD-EDE)

Chief of Engineers
ATTN: DAEN-MPO-B
ATTN: DAEN-MPO-U
ATTN: DAEN-MPZ-A

National Defense Headquarters
Director General of Construction
Ottawa, Ontario, Canada K1A 0K2

Airports and Const. Services Dir.
Technical Info. Reference Centre
Ottawa, Ontario, Canada K1A 0N8

Aberdeen Proving Ground, MD 21005
ATTN: AMXHE

Ft. Belvoir, VA 22060
ATTN: Learning Resources Center
ATTN: ATSE-TD-TL (2)
ATTN: Kingman Bldg, Library
ATTN: Canadian Liaison Officer (2)
ATTN: British Liaison Officer (5)

Ft. Leavenworth, KS 66027
ATTN: ATZLCA-SA

Ft. Monroe, VA 23651
ATTN: ATEN-AD (3)
ATTN: ATEN-FE-E

Ft. Lee, VA 23801
ATTN: DRXMC-D (2)

Ft. McPherson, GA 30330
ATTN: AFEN-CD

5th US Army
ATTN: AKFB-LG-E

6th US Army
ATTN: AFKC-EN

7th US Army
ATTN: AETTM-HRD-EHD

US Army Engineer District
- New York
  - ATTN: Chief, NANEN-E
  - ATTN: Chief, Design Br.
- Pittsburgh
  - ATTN: Chief, Engr Div
- Philadelphia
  - ATTN: Chief, NAPEN-E
- Baltimore
  - ATTN: Chief, Engr Div
- Norfolk
  - ATTN: Chief, NAOEN-R
- Huntington
  - ATTN: Chief, ORHED-P
- Wilmington
  - ATTN: Chief, SAWEN-PP
  - ATTN: Chief, SAWEN-PM
  - ATTN: Chief, SAWEN-E
- Charleston
  - ATTN: Chief, Engr Div
- Savannah
  - ATTN: Chief, SASAS-L

US Army Engineer District
- Jacksonville
  - ATTN: Env. Res. Br.
- Nashville
  - ATTN: Chief, ORNED-P
- Memphis
  - ATTN: Chief, LMMED-PR
- Vicksburg
  - ATTN: Chief, Engr Div
- Louisville
  - ATTN: Chief, Engr Div
- St. Paul
  - ATTN: Chief, ED-ER
- Chicago
  - ATTN: Chief, NCCPD-ER
  - ATTN: Chief, NCCPE-PES
- St. Louis
  - ATTN: Chief, ED-B
- Kansas City
  - ATTN: Chief, Engr Div
- Omaha
  - ATTN: Chief, Engr Div
- Little Rock
  - ATTN: Chief, Engr Div
- Tulsa
  - ATTN: Chief, Engr Div
- Fort Worth
  - ATTN: Chief, SWFED-PR
  - ATTN: Chief, SWFED-F
- Galveston
  - ATTN: Chief, SWGAS-L
  - ATTN: Chief, SWGCO-M
- Albuquerque
  - ATTN: Chief, Engr Div
- Los Angeles
  - ATTN: Chief, SPLED-E
- San Francisco
  - ATTN: Chief, Engr Div
- Sacramento
  - ATTN: Chief, SPKED-D
- Far East
  - ATTN: Chief, Engr Div
- Seattle
  - ATTN: Chief, NPSEN-PL-WC
  - ATTN: Chief, NPSEN-PL-ER
  - ATTN: Chief, NPSEN-PL-BP
- Walla Walla
  - ATTN: Chief, Engr Div
- Alaska
  - ATTN: Chief, NPASA-R

US Army Engineer Division
- New England
  - ATTN: Laboratory
  - ATTN: Chief, NEDED-E
- South Atlantic
  - ATTN: Chief, SADEN-E
- Huntsville
  - ATTN: Chief, HNDED-CS
  - ATTN: Chief, HNDED-M
- Lower Mississippi Valley
  - ATTN: Chief, PD-R
- Ohio River
  - ATTN: Chief, Engr Div
- North Central
  - ATTN: Chief, Engr. Planning Br.
- Southwestern
  - ATTN: Chief, SWDCO-O
- South Pacific
  - ATTN: Laboratory
- Pacific Ocean
  - ATTN: Chief, Engr Div
  - ATTN: Chief, PODED-P
- North Pacific
  - ATTN: Laboratory
  - ATTN: Chief, Engr Div

McClellan AFB, CA 95652
2852 APG/DE

Tinker AFB, OK 73145
2854 ABG/DEEE

Patrick AFB, FL 32925
ATTN: XRQ

AF/RDXT
WASH DC 20330

AFESC/PRT
Tyndall AFB, FL 32403

Little Rock AFB
ATTN: 314/DEEE

Kirtland AFB, NM 87117
ATTN: DEP

US Naval Oceanographic Office
ATTN: Library
Bay St. Louis, MS 39522

Naval Facilities Engr Command
ATTN: Code 04
Alexandria, VA 22332

Port Hueneme, CA 93043
ATTN: Library (Code L08A)
ATTN: Morell Library

Washington, DC
ATTN: Building Research Advisory Board
ATTN: Transportation Research Board
ATTN: Library of Congress (2)
ATTN: Dept. of Transportation Library

Dept. of Transportation
Tallahassee, FL 32304

Severinghaus, William D.
Effects of tactical vehicle activity on the mammals, birds, and vegetation in ecological systems / by W. D. Severinghaus ... (et al.) - Champaign, IL : Construction Engineering Research Laboratory ; available from NTIS, 1981.
18 p. (Technical report ; N-113)

1. Natural history - Texas. 2. Ft. Hood, TX. 3. Man-influence on nature. 4. Tanks (military science) - environmental aspects. I. Goran, William D. II. Schnell, Gary D. III. Johnson, Forrest L. IV. Title. V. Series: U. S. Army Construction Engineering Research Laboratory. Technical report ; N-113.